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NOTES ON GEOGRAPHIC DISTRIBUTION

New data on the distribution of *Homonota rupicola* Cacciali, Ávila & Bauer, 2007 (Squamata, Phyllodactylidae) in Paraguay

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Abstract. Of the few endemic vertebrates found in Paraguay, *Homonota rupicola* Cacciali, Ávila & Bauer, 2007 is considered micro-endemic, globally threatened, absent in conservation units, and restricted to rocky outcrops in a small mountain range, a priority hotspot, known as Cordillera de los Altos. Through sampling efforts in areas surrounding the type locality, we recorded *H. rupicola* at other sites. Together the current geographic range of this species is approximately 13 km along a segment of the Cordillera de los Altos. Nonetheless, *H. rupicola* is currently unknown from any protected areas, and non-governmental organizations are working towards establishing conservation units within the geographic range of the species.

Key words. Gekkota, geographic range extension, Neotropics, reptiles

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INTRODUCTION

Homonota rupicola Cacciali, Ávila & Bauer, 2007 is a nocturnal neotropical gecko belonging to the *borellii* group, and along with *H. taragui* Cajade, Etchepare, Falcione, Barrasso & Álvarez, 2013 (its sister species), *H. borellii* (Peracca, 1897), and *H. uruguayensis* (Vaz-Frreira & Sierra de Soriano, 1961) form the basal clade in the group (Morando et al. 2014; Cacciali et al. 2017). This gecko is endemic to Paraguay, described originally by Cacciali et al. (2007) based on four specimens from a single locality—Cerro Pedregal, Cordillera department, Paraguay. Six additional specimens from the same known locality were subsequently reported, based on material housed in the Collección Herpetológica "Lic. Blanca Beatriz Alvarez", Universidad Nacional del Nordeste, Corrientes, Argentina (Cacciali et al. 2015a).

The habitat where *H. rupicola* occurs is a landscape of rocks covered by lichens, giving the surface a reticulated color pattern used by the lizards for mimesis. The sister species, *H. taragui*, inhabits a similar environment, and it also has a very narrow geographic range restricted to just three rocky hills in Corrientes, Argentina (Cajade et al. 2013). The possible isolation of these species likely occurred between 4 and 2.5 million years ago, after the rise of the Paranean Sea (Morando et al. 2014). The type locality, and the only known locality so far, of *H. rupicola* is Cerro Pedregal (25°31′07″S, 057°02′53″W), an outcrop on a rocky hill, part of the Cordillera de los Altos mountain range (Cacciali et al. 2007), which constitutes an endemism hotspot (Avila-Torres et al. 2023).

Following the original description, scattered and sporadic attempts to find additional populations of the species from areas surrounding the type locality were conducted, but were unsuccessful. *Homonota rupicola* is a cryptic, nocturnal species, and for these reasons it may not have been found in other areas.

In 2021 we initiated a project focusing on improving the knowledge of the distribution of *H. rupicola*; details of this project are provided in the Acknowledgments. The purpose of this study is to accurately assess the long-term threats to the species and its risk of extinction. Based on that project, we investigated areas near the type locality and other areas with similar environments to confirm the species' extent of occurrence (EOO), which is among the criteria used by the International Union for Conservation of Nature (IUCN 2012) to determine conservation status of species. Here, we increase the known geographic distribution of *H. rupicola* and improve the knowledge of this poorly known endemic species.

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Figure 1. Landscape where *Homonota rupicola* is present in Cordillera Department, Paraguay.

METHODS

We conducted field surveys in several locations at the Cordillera de los Altos hill range, during different seasons between 2021 and 2023. Surveys were undertaken by 3–5 persons in each field trip, for total search effort of approximately of 117 person-days. We sampled specimens through active searches, seeking them out on the ground and in potential shelters, such as in crevices and under rocks. Surveys began at dusk and continued until midnight. Because of the specific habitat of *H. rupicola*, searches were conducted in rocky habitat with patches of mixed forests, along creeks, and associated gallery forests (Figure 1). Each survey was carried out in groups of at least three researchers, given the necessity of collaboration while handling large rocks in this type of environment (Cacciali 2013). The total area sampled was approximately 4.79 km^2 (Figure 2).

To estimate the area of occurrence, we calculated the EOO (the minimum convex polygon in which internal angles does not exceed 180° and contains all occurrences) following the IUCN method (Rodrígues et al. 2015). Elevation information was obtained from the Consortium for Spatial Information (CSI 2008) available at http://www.diva-gis.org/gdata and using SRTM30 (30′ resolution) datasets.

Although *H. rupicola* is the only known species of this genus to occur in the area, we photographed specimens to keep records and collected three specimens as vouchers. Sodium thiopental by intraperitoneal injection was used for euthanasia (Simmons 2002). These collected specimens were deposited in the herpetological collection of the Museo Nacional de Historia Natural del Paraguay (**MNHNP**), San Lorenzo, Paraguay (Sabaj 2023). Collection permits were issued by Ministerio del Ambiente y Desarrollo Sostenible (MADES no. 024/2020 and 004/2022).

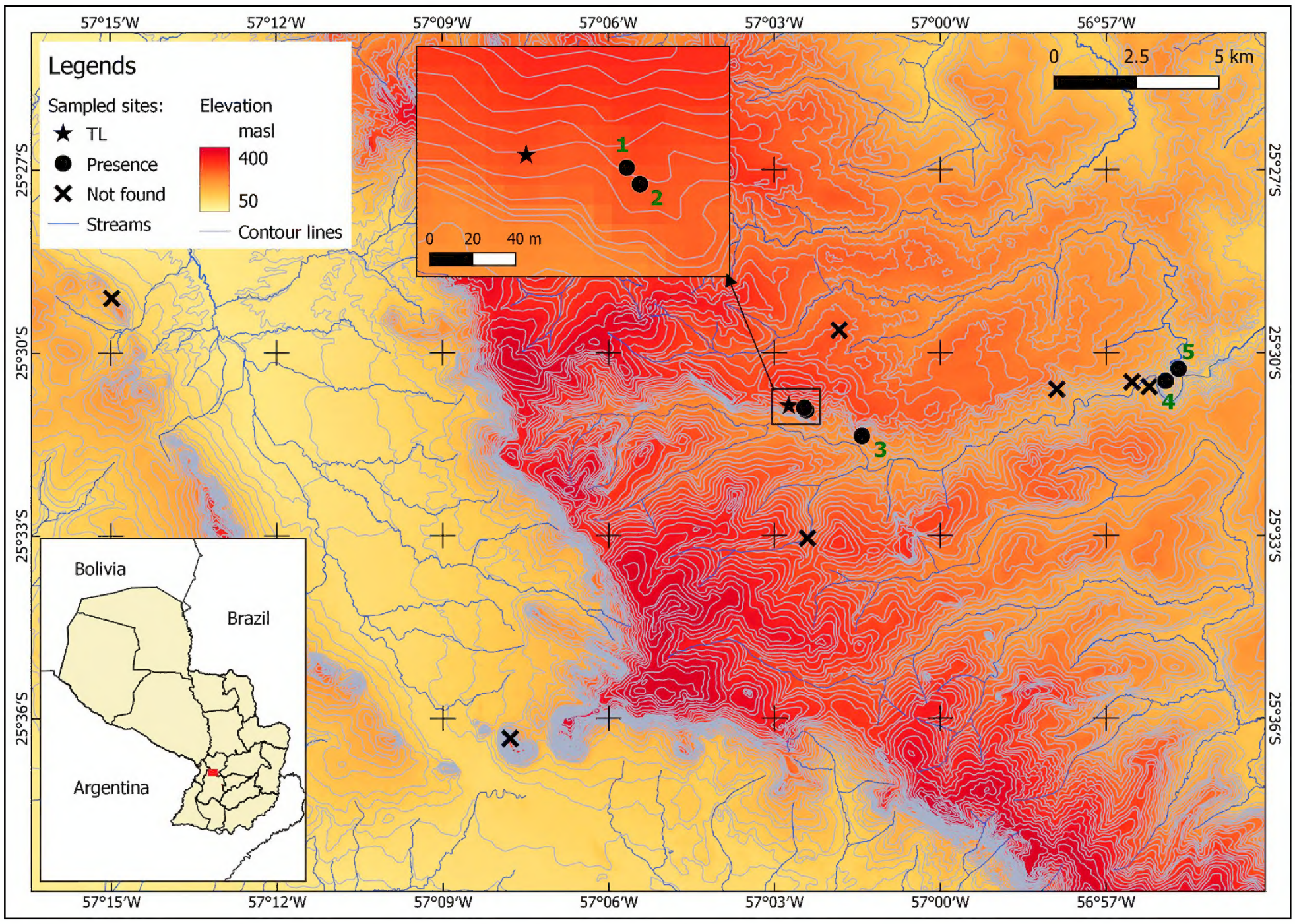

Figure 2. Sampling areas during this study, showing type locality (star), sites where the species was not found ('x' marks), and sites where the presence of *Homonota rupicola* was confirmed (black dots) which correspond to Cerro Naranjo 1 (1), Cerro Naranjo 2 (2), Itá Morotĩ (3), Piraretá (4), and near Salto Piraretá (5).

RESULTS

Class Reptilia Linnaeus, 1758
Order Squamata Oppel, 1811
Suborder Gekkota Camp, 1923
Family Phyllodactylidae Gamble, Bauer, Greenbaum & Jackman, 2008

***Homonota rupicola* Cacciali, Ávila & Bauer, 2007**
Figure 3

New records. PARAGUAY – Cordillera Department • Cerro Naranjo 1; 25°30′54″S, 057°02′27″W; 297 m elev.; 11.VII.2021; N. Cantero, L. Cañete, S. Escobar obs.; 8 spec., adults and juveniles • Cerro Naranjo 2; 25°30′57″S, 057°02′25″W; 290 m elev.; 17.IX.2022; N. Cantero, L. Cañete, S. Escobar, M. Bóveda obs.; 10 spec., adults and juveniles • Itá Morotĩ; 25°31′22″S, 057°01′24″W; 252 m elev.; 01.IV.2023; P. Cacciali, J. Maciel, N. Justiniano obs.; 15 spec., adults and juveniles • Piraretá; 25°30′27″S, 056°55′55″W; 174 m elev.; 09.IX.2022; P. Cacciali, J. Maciel, L. Sforza, A. Spangenberg obs.; 9 spec., adults and juveniles • same location and date; P. Cacciali leg.; 1 spec., adult, MNHNP 12920 • Near Salto Piraretá; 25°30′15″S, 056°55′41″W; 148 m elev.; 08.IX.2022; P. Cacciali, J. Maciel, L. Sforza, A. Spangenberg obs.; 7 spec., adults and juveniles • same location and date; P. Cacciali leg.; 2 spec., adults, MNHNP 12919 & MNHNP 12921.

Identification. The specimens are identified as *H. rupicola* based on pattern of irregular dark (when the background color is light gray) or light gray (when the background color is dark gray or brown) reticulations or mottling; the venter is gray (or lighter gray with the presence of melanophores) (Cacciali et al. 2007). Dorsally, this species has a series of enlarged keeled scales, and the absence of keeled scales on the sides of the head (other species in Paraguay of *Homonota* have keeled tubercles on the sides of the head). The SVL of our specimens ranged in from 35 mm (MNHNP 12921) to 38 mm (MNHNP 12920). Only MNHNP 12919 had a complete tail, which measured 59 mm. Head length (HL), head width (HW), eye diameter (ED), and tympanum diameter (TD) for the three specimens collected (MNHNP 12919–12921) are as follows: HL: 13.0/11.5/11.4 mm, HW: 7.5/7.8/7.4 mm, ED: 2.5/2.4/2.5 mm, TD: 0.9/1.2/1.2 mm.

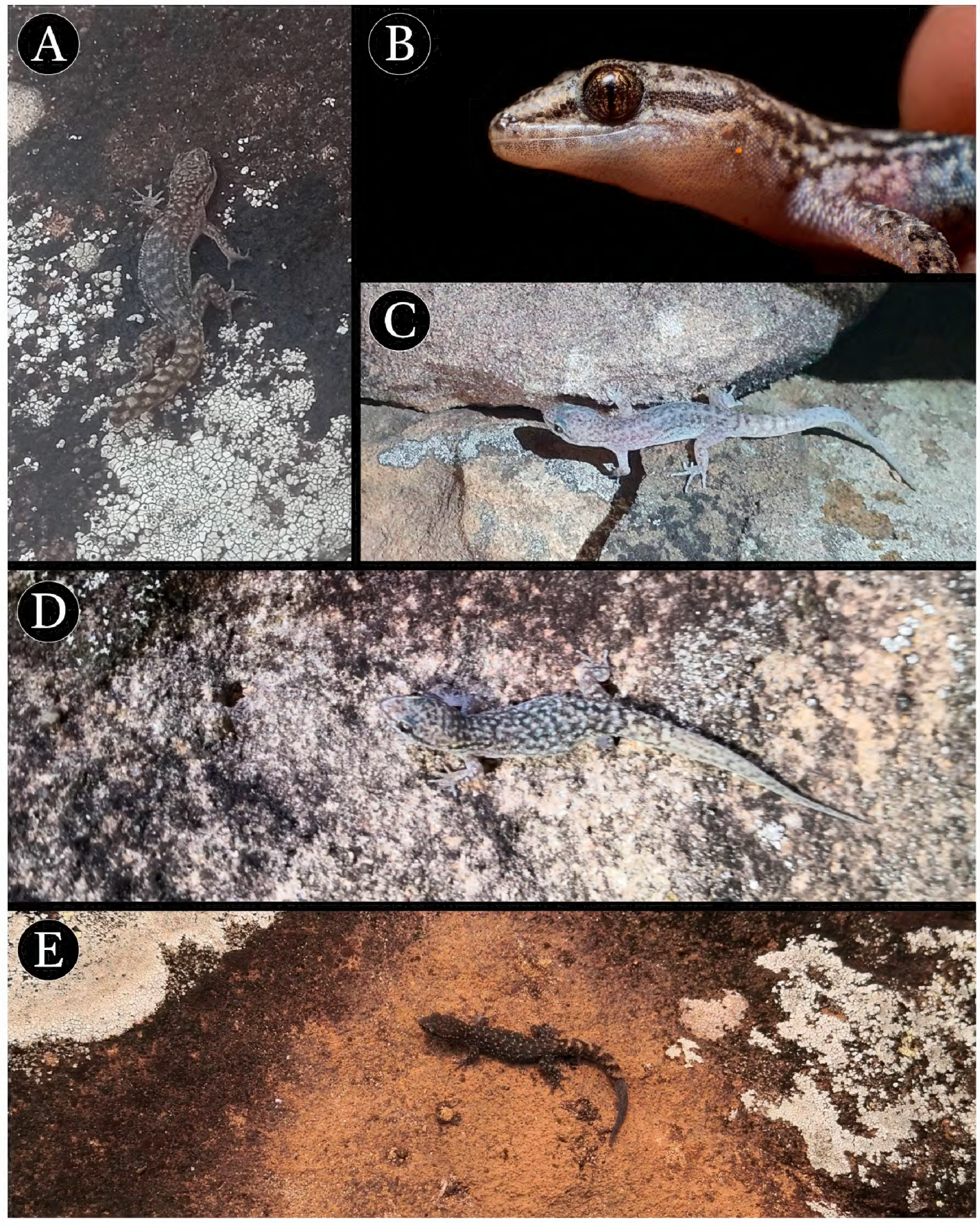

Figure 3. Specimens of *Homonota rupicola* from sampled areas. **A.** Cerro Naranjo 1. **B.** Cerro Naranjo 2. **C.** Itá Morotĩ. **D.** Piraretá. **E.** Near Salto Piraretá. Photographers: Lucas Cañete (A), Mario Bóveda (B), Natalia Justiniano (C), and Lorena Sforza (D and E).

DISCUSSION

It is critical to know the geographic distributional of an endemic species because it helps in understanding how the species has adapted to its specific environment and how it interacts with other species, as well as with threats and challenges it faces (Burlakova et al. 2011). The Cordillera de los Altos is a priority conservation hotspot according to a multi-scale study that included several taxonomic groups (Avila-Torres et al. 2023). However, no protected areas properly encompass this hotspot. Although we have expanded the known distribution of *H. rupicola* by up to 12.1 km east of the type locality (near Salto Piraretá), this species has not been recorded in a protected area or areas adjacent. This is of concern because habitat loss due to anthropogenic activities, such as mining, is the main threat to this species (Cacciali et al. 2015b; Martinez et al. 2020). Currently, the non-governmental organization Guyra Paraguay is looking for alliances to establish protected areas within the geographic range of *H. rupicola* which will help protect of this species.

Even when endemic lizard species occur in conservation units, species with restricted ranges are still prone to extinction, and conservation efforts must focus on protecting these lineages (Meiri et al. 2017). Examples of lizards that had severely restricted geographic ranges and that were driven to extinction are *Cynisca gansi,* Dunger, 1968 (Amphisbaenidae) (Luiselli and Chirio 2013), *Capitellum metallicum*, (Bocourt, 1879) (Scincidae) (Hedges and Powell 2016), *Lepidodactylus gardineri*, Boulenger, 1897 (Gekkonidae) (Oliver and Fisher 2021), and *Mabuya grandisterrae*, Hedges & Conn, 2012 (Scincidae) (Powell and Dewynter 2021). Currently, we estimate the EOO of *H. rupicola* is about 13 km^2, which is important information to have for its conservation. Additional searches for this species in similar habitats are needed to potentially discover new populations in Paraguay, and molecular genetic analyses would be extremely beneficial in establishing other conservation perspectives, not only for *H. rupicola*, but for other reptile species as well.

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ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

Specimens were euthanized using recommended anesthetics and endorsed by MADES.

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Author contributions

Conceptualization: PC, NC, DT. Data curation: PC, NC, LC. Funding acquisition: NC, DT. Investigation: PC, NC. Methodology: PC, NC. Resources: NC, LC. Supervision: PC, DT. Visualization: PC. Project administration: NC. Validation: DT. Writing – original draft: PC. Writing – review and editing: NC, LC, DT.

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Data availability

All data that support the findings of this study are available in the main text.

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